Design leakage rates for activity release calculation

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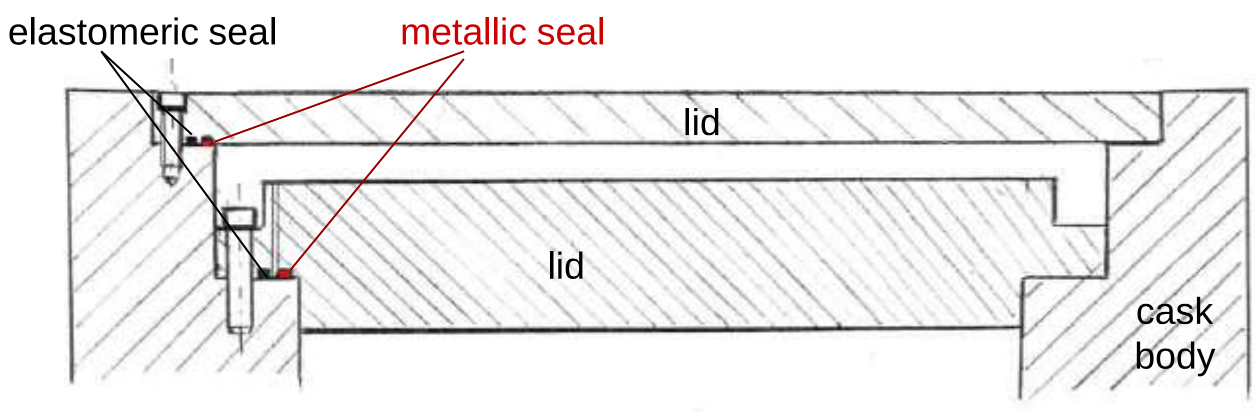
Content of most of the slides is taken over from:
„Verification of Design Leakage Rates for Activity Release Calculation“, A.Rolle, H.-P.Winkler, U.Probst, V.Ballheimer, T.Neumeyer
PATRAM 2013, August 18-23, 2013,San Francisco, CA,USA

Content:

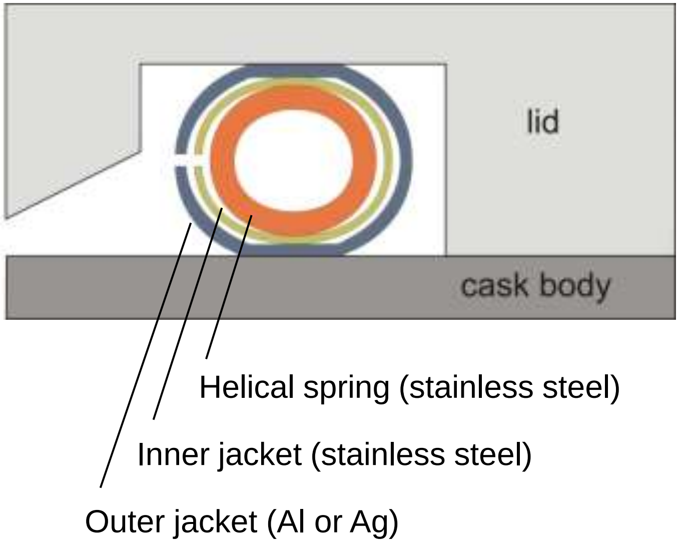
1.Introduction (transport conditions and their influence on design leakage rate)
2.Influence of a dynamic lateral lid displacement on the leak tightness
3.Influence of time and temperature on the seals useful elastic recovery
4.Conclusions

BAM

Sealing system of transport and storage casks



Metallic gasket, Helicoflex[R] -type



Limits for activity release from Type (B) packages

(IAEA Specific Safety Requirements SSR-6, § 659):

Normal Conditions of Transport (**NCT**):	**10^{-6} A_2 per hour**	**[Bq]**
Accident Conditions of Transport (**ACT**):	**A_2 per week**	**[Bq]**
	(10 A_2 per week for Kr-85)	

Possible effects of impacts to be considered (according to IAEA, SSR-6) on sealing system:

Impacts:

RCT (§613, §616)

- acceleration (2 g) in radial and axial directions
- operational temperature and pressure

NCT (§722)

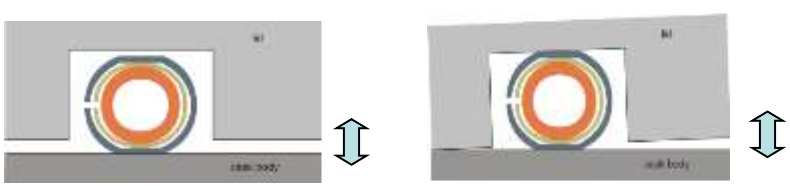
- free drop from 0.3 m in transport position

ACT (§726 to §728)

- free drop from 9 m
- 1m puncture test
- 800°C, 30 min
- water immersion test

Possible effects:

unloading and widening



lateral sliding

rotation

Deducing of covering design leakage rates

Design leakage rates:

- deduced from tests with real casks, models of cask or cask components relating to normal and accident transport conditions
- identify the efficiency limit of the sealing system
- basis for calculation of activity release

Attention: Extrapolation of leakage rates measured at scaled models or components to real casks might be difficult. (see IAEA Advisary, §701.25)

Lateral lid movement

possible sliding distance
depending on cask design
and manufacturing tolerances

Existing test results for leakage rates after lateral sliding of metallic seals:

- *quasi- static lateral displacement tests (up to 3 mm) (Schubert, 2009):* $Q_{SLR\ He} < 10^{-8} Pam^3s^{-1}$
- *dynamic sliding tests (up to 3 mm displacement) (Marlier, 2008):* $Q_{SLR\ He} < 10^{-8} Pam^3s^{-1}$
- *static and dynamic sliding tests (up to about 3 mm displacement) (Shirai, 2010):* $Q_{SLR\ He} < 10^{-6} Pam^3s^{-1}$

BAM requires tests for verification of the sealing behaviour after a dynamic lid displacement **in the relevant range depending on cask design,** which can be **greater than 3 mm.**

Test program :Dynamic seal displacement

- Helicoflex seals type HN 200, outer jackets Al and Ag,

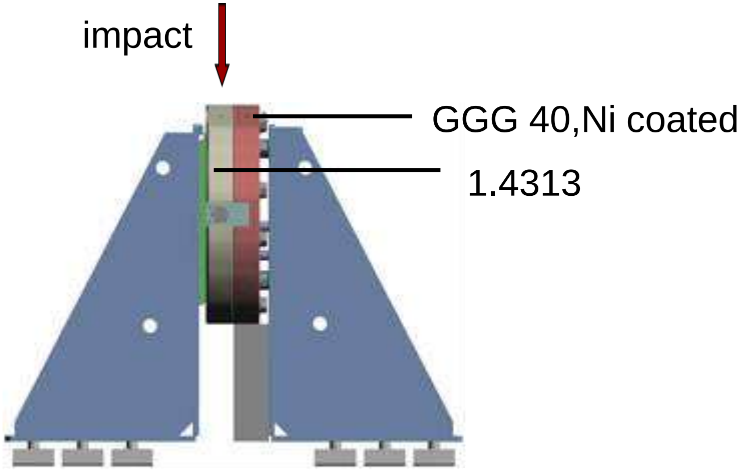
  torus 9.9 mm (Al), torus 9.7 mm (Ag) , circumference 1 m

- flange materials identical to real cask designs (Ni coated GGG 40 and 1.4313)

- distance of displacement in the range of lid movement possible for real cask designs

Test series with silver and aluminum seals:

1) **ambient temperature, not aged seal**
2) **ambient temperature, aged seals**
3) **-40°C, not aged seals**
4) **-40°C, aged seals**



flange assembling

Drop test machine for guided drop tests at the BAM “Test Site Technical Safety (TTS)“

lifting system

guiding system
with slide rails

electromechanical
release system

drop weight

Parameters:	
Max. height:	14,2 m
Max. drop height:	12,0 m
Max. drop weight:	1 000 kg
Max. impact energy:	118 kJ
Max. impact velocity:	15,3 m / s
Max. impact pad:	18 000 kg
Impact area:	2 m x 2 m

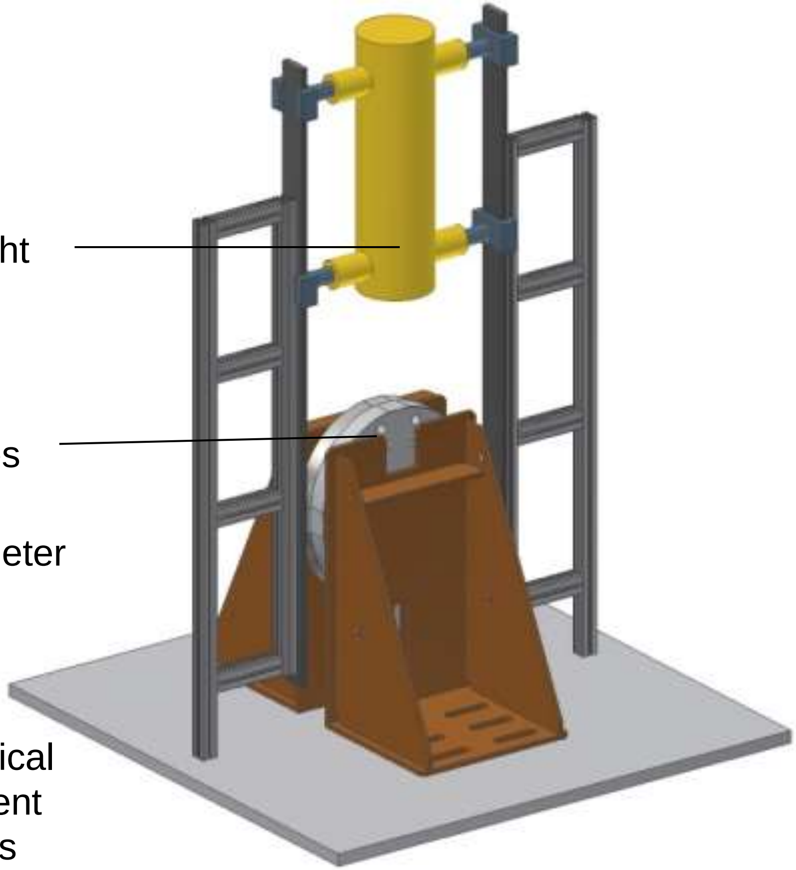
fluide muscles

drop weight

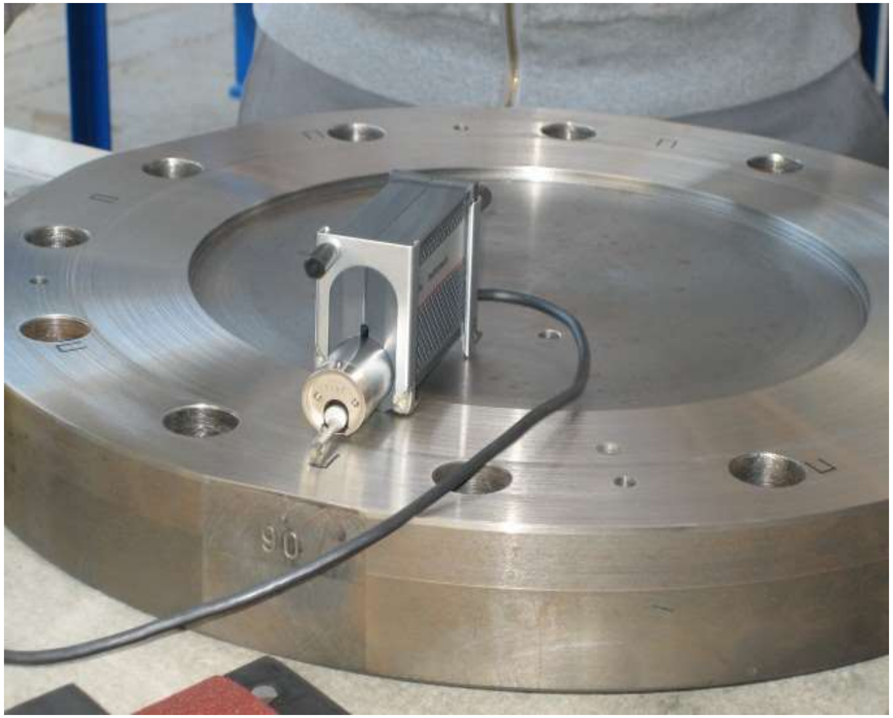
test flanges

accelerometer

electro-optical displacement transducers

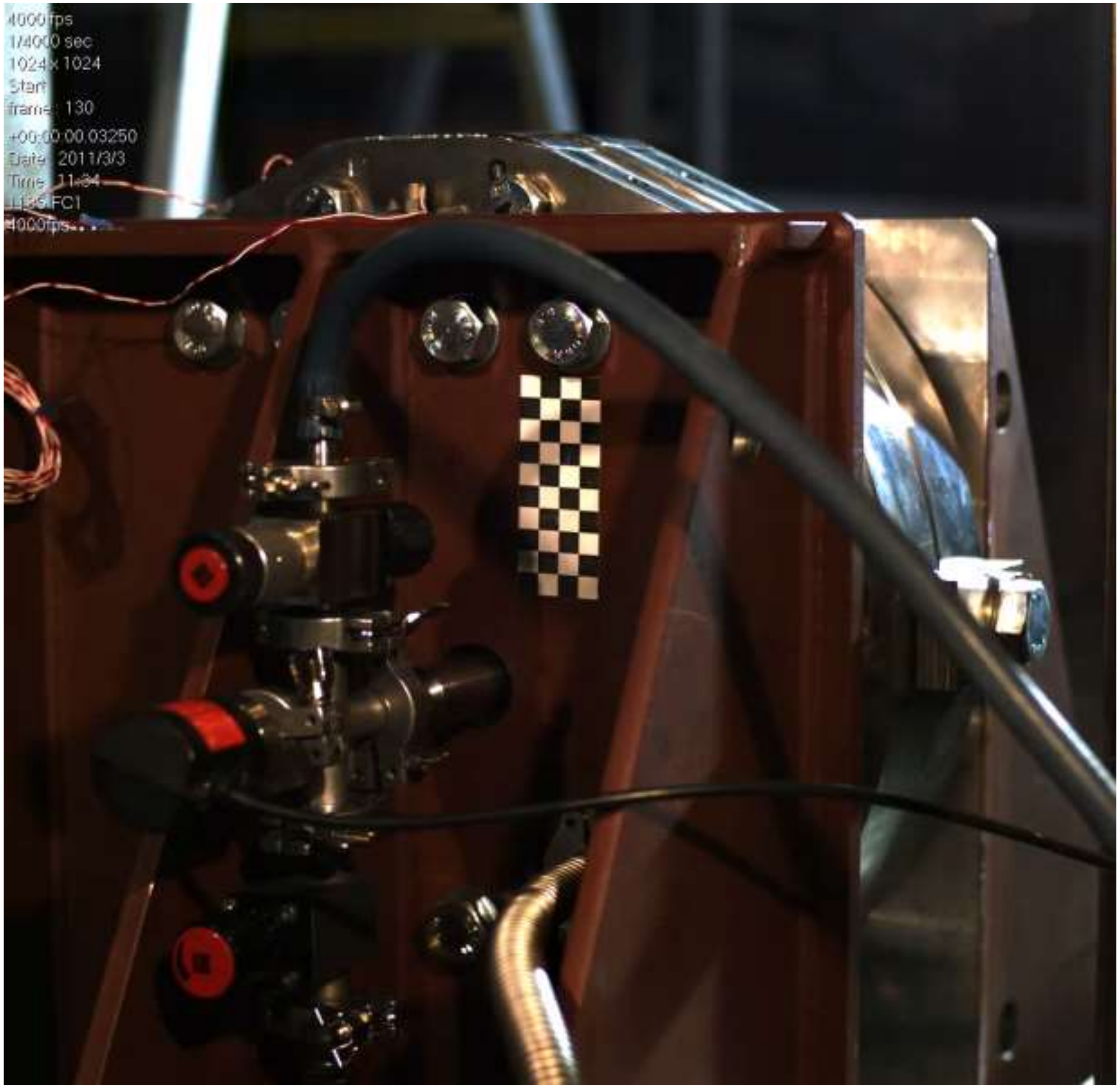


- measurement of displacement by an electro-optical method
- accelerometers at flanges and drop weight
- simultaneous He- leakage measurement with UL 200



Measurement of surface roughness

Eccentric fitting after inserting the seal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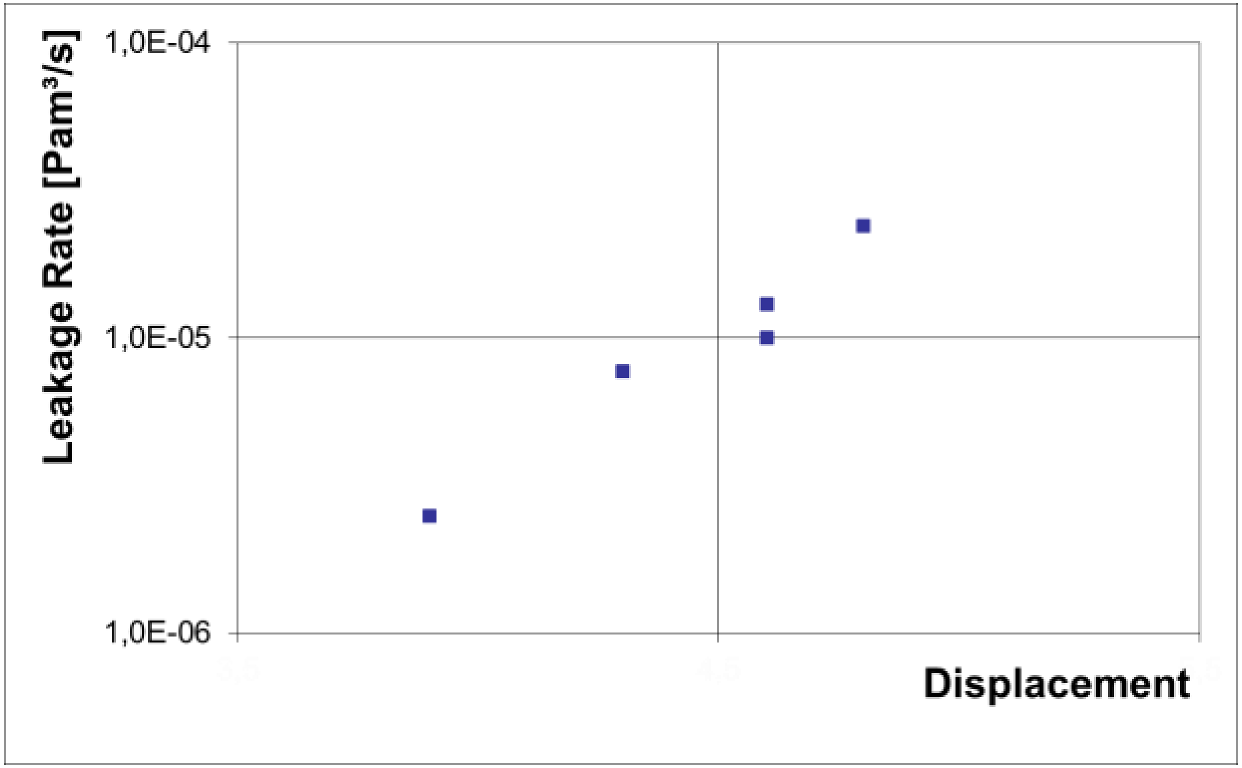
1/4000 sec
1024 x 1024
Start
frame : 130
+00:00:00.03250
Date : 2011/3/3
Time : 11:34
4000fps

Deformation of the seal after lateral displacement

Al- jacket seal after a sliding test

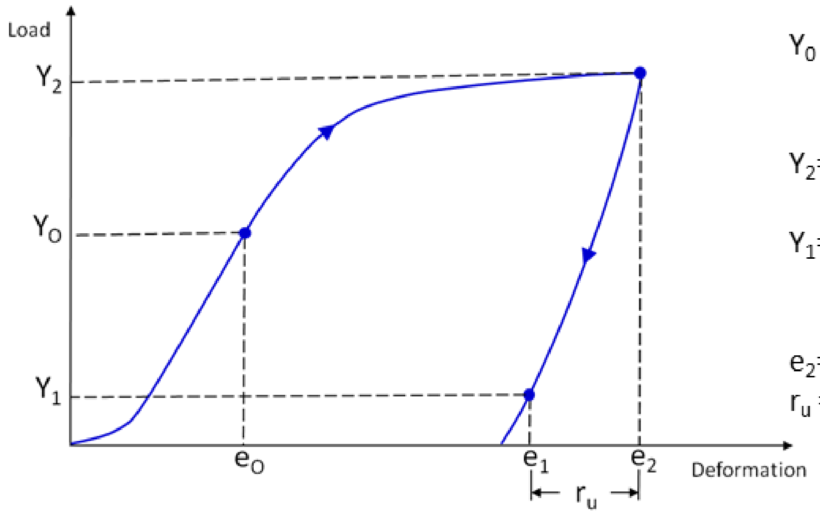
First results: Leakage rates after lateral displacement

Al- seals, RT, initial value before displacement < 1,0E-08 Pam^3s^{-1}



- Significant increase of leakage after dynamic lateral displacement
- Clear dependency of the leakage rate on the sliding distance

Illustration of the useful elastic recovery r_u of a metallic seal

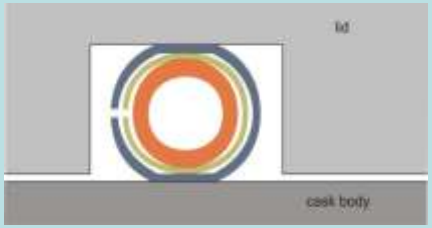


Y_0 = load on the compression curve above which leakage rate is at required level
Y_2 = load required to reach optimum compression e_2
Y_1 = load on the decompression curve below which leakage rate exceeds required level
e_2 = optimum compression
r_u = useful elastic recovery (e_2-e_1)

r_u

(according to a description in www.techneticsgroup.com)

necessary condition for leakage rates < 10^{-8} Pa m^3s^{-1} :

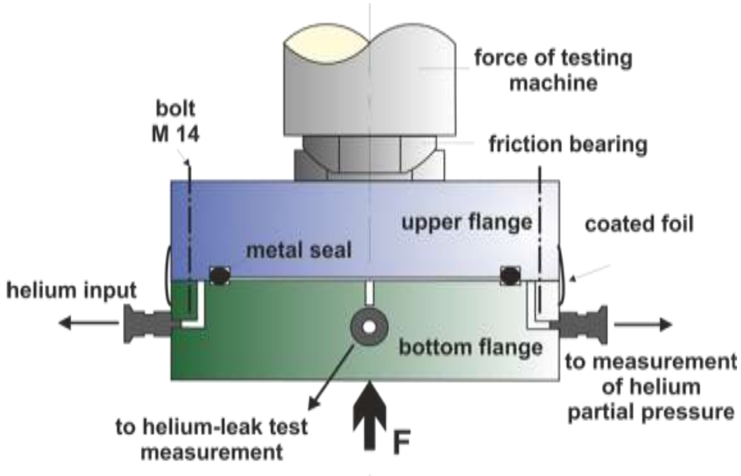


permitted widening < r_u

$r_u = e_2 - e_1$,characterizes the efficency of the seal to compensate decompression.

Below Y_1 the leakage rate exceeds the level of 1E-8 Pam^3s^{-1}.

BAM investigations for time and temperature depending seal behaviour [according to presentation of H. Völzke et al: Long-term Performance of Metal Seals of Transport and Storage Casks]

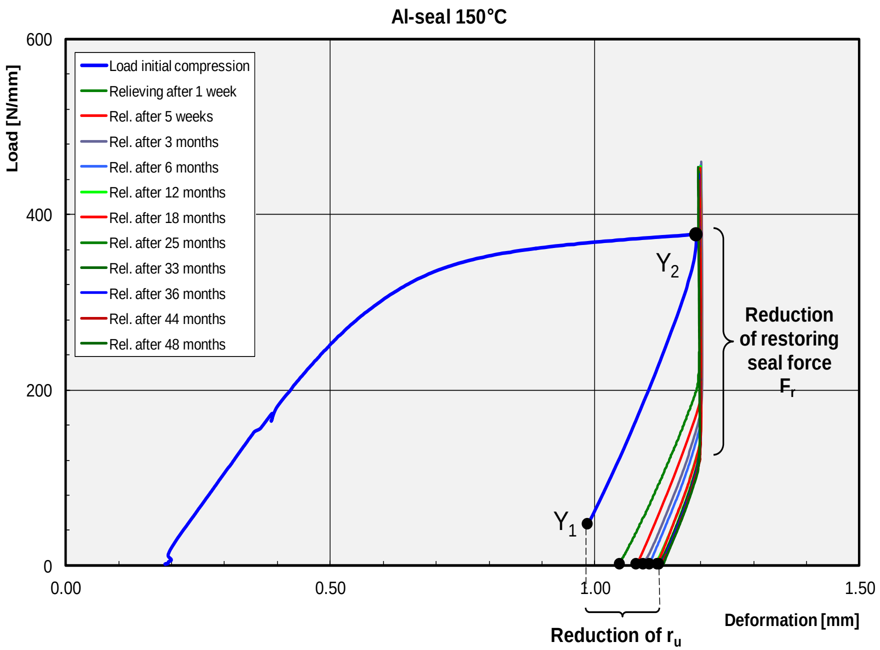


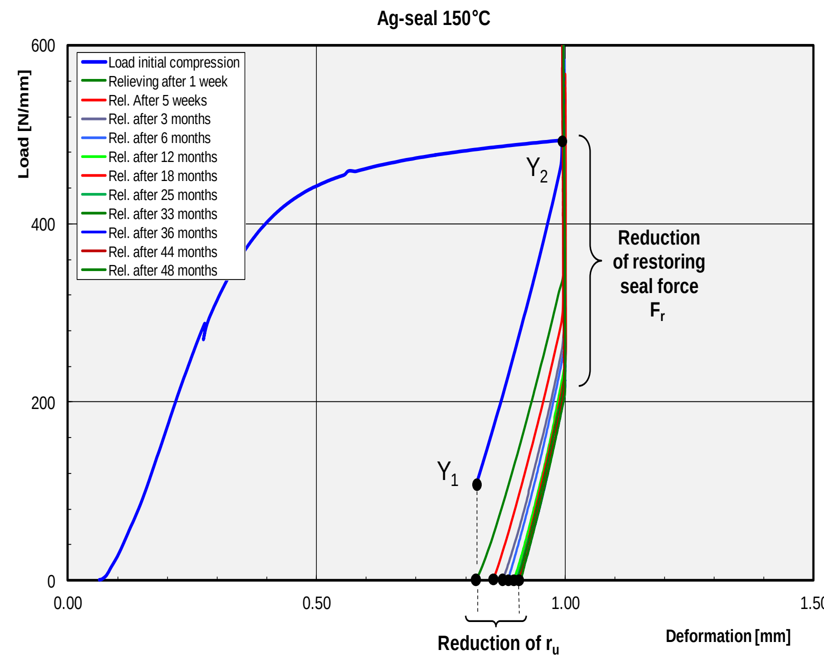
- storage temperatures: RT, 100°C, 150°C
- tempering time up to now: 48 month
- periodical measurements of r_u

BAM test flanges, open and closed configuration

Al-seal, 150°C

Ag-seal, 150°C





significant reduction of r_u during storage at higher temperatures

In this example:

Al- seal: from r_u = **0.18** mm to **0.09** mm (after 12 month)

Ag- seal: from r_u = **0.17** mm to **0.11** mm (after 12 month)

Test program at CEA/ Technetics Group-Test Lab ,Pierrelatte

- 70 test flange systems with Al- and Ag- Helicoflex seals type HN 200
- test period: one year
- storing temperatures: RT, 100°C, 130°C, 150°C
- measuring of r_u and Y_2 after 10, 40, 100, 200 and 365 days

→ bounding r_u- values for Al- and Ag- seals of the Helicoflex type

upper flange, roughness measuring

bottom flange with seal

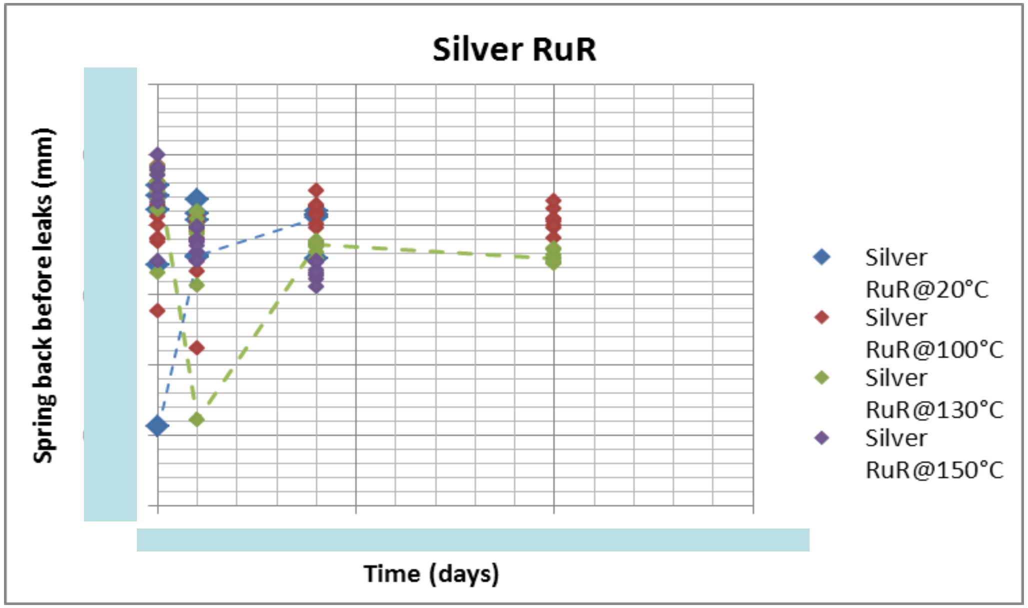
He-leakage rate measurement

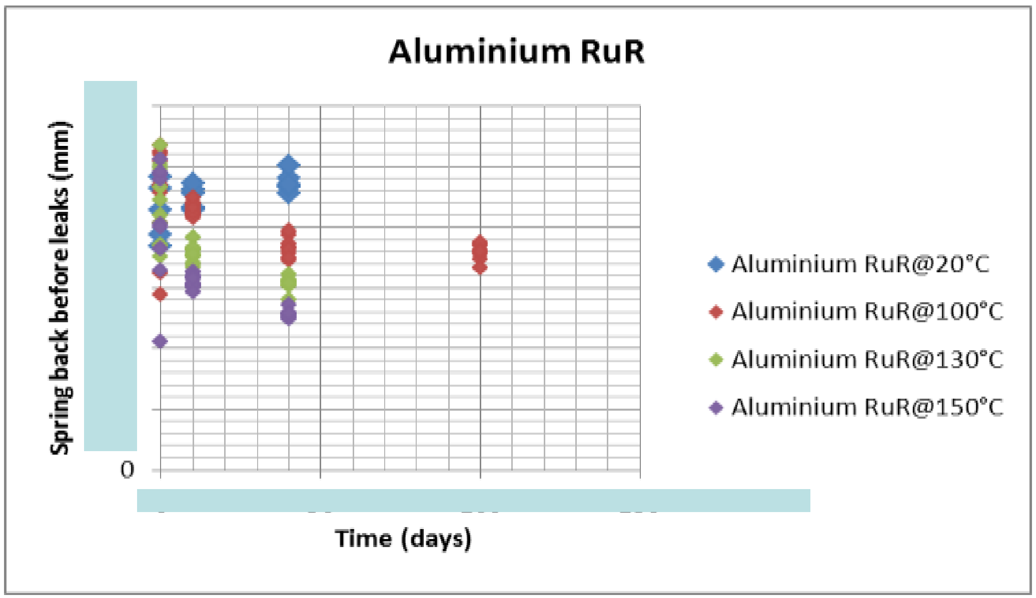
testing machine

Three ovens are available for storing at CEA/ Technetics group Lab .

monitoring of seal temperature

First results





Cited from the interim report by Technetics Group:

Ru drift Program, Aging of metallic seals
June 25 th, 2013

F. Ledrappier, C. Darles, J.F. Juliaa

Testseries are running, results are expected for the end of 2014

Current approach:

$r_{u,\ allowable} = 0.5 \times r_u$

Safety factor considers the current uncertainty about potential reduction of r_u under operational condition

Conclusion

For verification of activity release compliance two important test programs are still running:

1) influence of a dynamic lid displacement on the standard leakage rate of a metallic seal

2) influence of time and temperatur on the useful elastic recovery of a metallic seal

The results expected will be qualified to specify the boundary conditions of release calculation in a conservativ way. Existing results up to now seem to confirm the stringent benchmarking requiered up to now by BAM.